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REPORT OF INVESTIGATIONS—NO. 84

LATERAL VARIATION IN CHESTER SANDSTONES PRODUCING OIL AND GAS IN LOWER WABASH RIVER AREA

WITH SPECIAL REFERENCE TO NEW HARMONY FIELD

BY
GEORGE V. COHEE

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Topographic Mapping in Cooperation with the United States Geological Survey.

This Report is a Contribution of the Oil and Gas Division.

August 1, 1942

LATERAL VARIATION IN CHESTER SANDSTONES PRODUCING OIL AND GAS IN LOWER WABASH RIVER AREA, WITH SPECIAL REFERENCE TO NEW HARMONY FIELD, ILLINOIS AND INDIANA[1]

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ABSTRACT

Much oil is produced in the region of the lower Wabash River which is the boundary between Illinois and Indiana in this area. Oil and gas are produced from lower Pennsylvanian and Chester (upper Mississippian) sandstones and from the Fredonia limestone (McClosky "lime") of the Ste. Genevieve formation (lower Mississippian series). The oil fields occur along a broad slightly folded anticline that roughly parallels the course of the river. The areal distribution of the oil pools is different for each producing formation and appears to be controlled to a greater degree by lensing sand conditions than by structure.

Oil and gas in the Wabash River valley in southeastern Illinois and southwestern Indiana are produced from lower Pennsylvanian and Chester sandstones and the Fredonia limestone (McClosky "lime") of the Ste. Genevieve formation. The principal fields in the area are New Harmony and Keensburg. These include an almost continuous producing area from Keensburg, Wabash County, Illinois, at the north, to the south side of Ribeyre Island, 3 miles southwest of New Harmony, Indiana (Fig. 1). This single area is approximately 18 miles long and varies in width from ½ mile to more than 2 miles at its widest point in White County, Illinois. On January 1, 1942, there were almost 1,000 producing wells in the two fields, and the productive area proved by drilling was 7,238 acres.

The fields along Wabash River in Wabash County and northeastern White County, Illinois, occur along a broad slightly folded anticline that roughly parallels the course of the river. Oil and gas along the anticline in general occur in local "highs" but the productive area of individual sands is more dependent on the sand characteristics than on structure. Most of the Chester sands in this area are very lenticular and considerable variation in thickness is noted from one well to another.

All of the eight Chester sandstone formations and additional sandstone beds in other Chester formations were found productive in one place or another throughout the area.

The rock strata comprising the Chester series in the lower Wabash River area are approximately 1,100 feet thick and are overlain by 1,800 feet of Pennsylvanian beds. The entire Chester sequence is present in part of the south half of the New Harmony field, but northward and into Wabash County the uppermost beds have been truncated by pre-Pennsylvanian erosion. In northern Wabash

[1] Read in part before the Association at Denver, April 24, 1942. Manuscript received, July 25, 1942.

[2] Assistant state geologist, Division of Geology. Department of Conservation, Indiana. Formerly assistant geologist, Illinois State Geological Survey, Urbana.

County there are 700 feet of Chester beds topped by the Menard formation which is directly overlain by Pennsylvanian strata; the Kinkaid, Degonia, Clore, and Palestine formations are absent. In addition to the truncation of the upper beds there is slight thinning of the formations northward.

The area considered in detail in the present paper is the New Harmony field. The field was discovered by the Superior Oil Company's New Harmony Realty

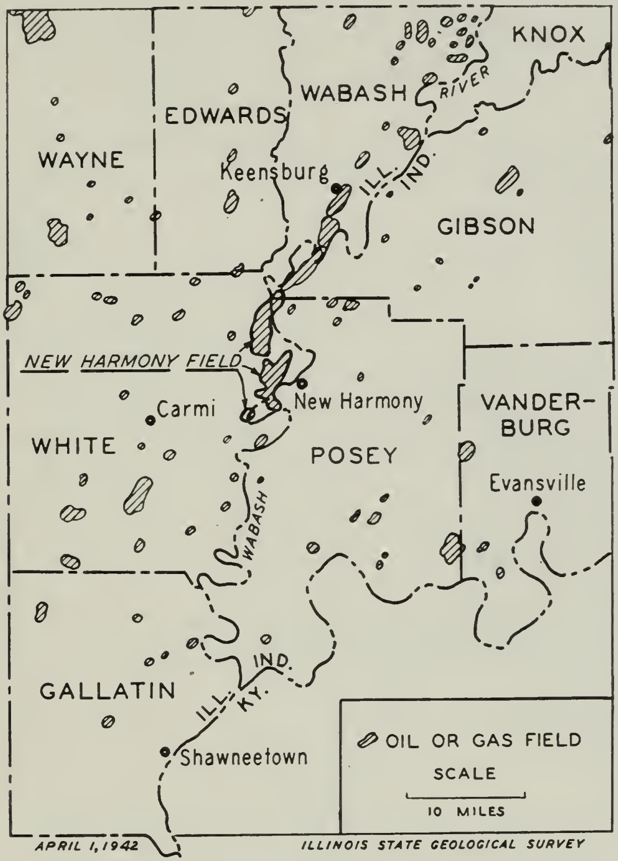

Fig. 1.—Location of New Harmony field in lower Wabash River area.

Corporation well No. 1, Sec. 5, T. 5 S., R. 14 W., Posey County, Indiana, at the south end of the present field. The well was completed, June, 1939, in the Waltersburg sandstone with initial production of 252 barrels a day flowing after testing the McClosky "lime." The field was rapidly developed, and by the end of 1941 it included a productive area of 5,000 acres in which there were 647 producing wells. The total production of crude oil at that time was 11,700,000 barrels, and the future reserves were estimated to be more than 20 million barrels.

Production in the field is principally from Chester sandstones that occur in irregular areas, and no one sand is productive throughout the field. The McClosky "lime" of lower Mississippian age is productive in some parts of the field, and the basal Pennsylvanian sandstone is productive in a small area.

As developed at present, the Bethel sandstone is productive over the largest area, approximately 3,300 acres; the Aux Vases sandstone is next with a productive area of 2,640 acres; and the Cypress sandstone is third with 2,000 acres. The area of Waltersburg, Tar Springs, and Paint Creek-Bethel[3] sandstone production is 750, 480, and 440 acres, respectively. There is a total of 9,610 acres of Chester sand production in the field. The average thickness of "pay" ranges from 15 to 25 feet.

A summary sample study log[4] of a representative well in the New Harmony field lists the following strata penetrated.

System, Series, or Formation	*Thickness (Feet)*	*Depth (Feet)*
No samples	130	130
Pennsylvanian system	1,695	1,825
Mississippian system		
Chester series		
Kinkaid limestone and shale	35	1,860
Degonia sandstone	15	1,875
Clore shale, sandstone, and limestone	55	1,930
Palestine sandstone and shale	80	2,010
Menard limestone and shale	130	2,140
Waltersburg sandstone and shale	25	2,165
Vienna shale and limestone	40	2,205
Tar Springs sandstone	135	2,340
Glen Dean limestone	50	2,390
Hardinsburg sandstone and shale	20	2,410
Golconda limestone and shale	205	2,615
Cypress sandstone	35	2,650
Paint Creek limestone and shale	80	2,730
Bethel sandstone	70	2,800
Renault limestone and shale (includes so-called Aux Vases limestone)	55	2,855
Aux Vases sandstone	25	2,880
Iowa series		
Ste. Genevieve formation	145	3,025
St. Louis limestone	49	3,074

STRUCTURE

Contours are drawn on the base of the basal Golconda limestone, a thin uniform limestone occurring throughout the field.

Structurally, the New Harmony field is apparently comprised of two anticlines, both trending northeast and southwest (Fig. 2). Two small domes with 10 to 20 feet of closure are present in the north half of the field and several irregular structures with closures up to 30 feet occur in the south half of the field.

Away from the field the rock strata dip gently eastward whereas westward the

[3] Some of the production reported to be from the Paint Creek sandstone in the north part of the field may be from the Bethel sandstone. Sufficient well data were not available in the particular area in question to establish the correlation.

[4] Samples studied by F. E. Tippie, Illinois State Geological Survey.

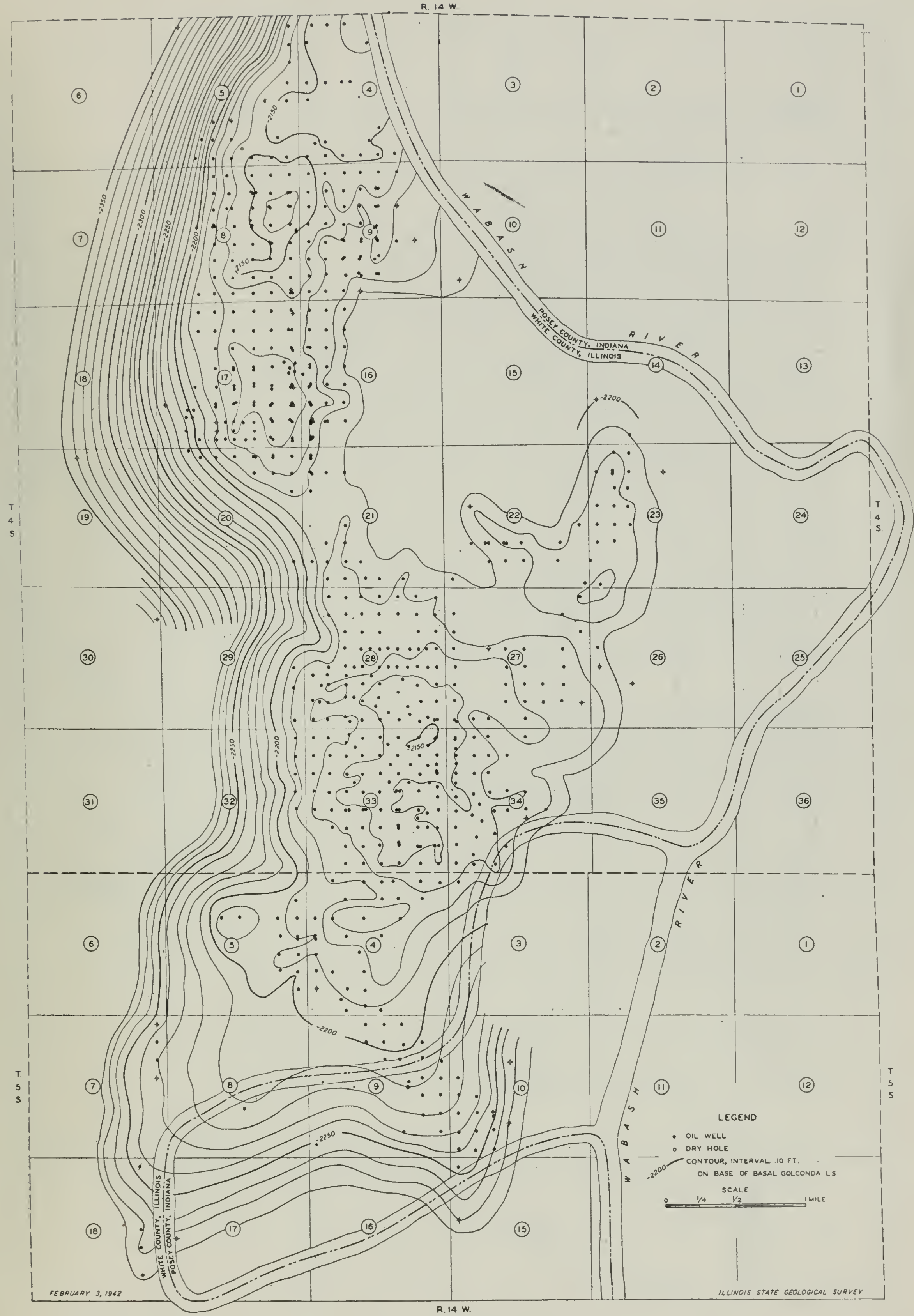

FIG. 2.—Structure map of New Harmony field. Contours on base of basal Golconda limestone.

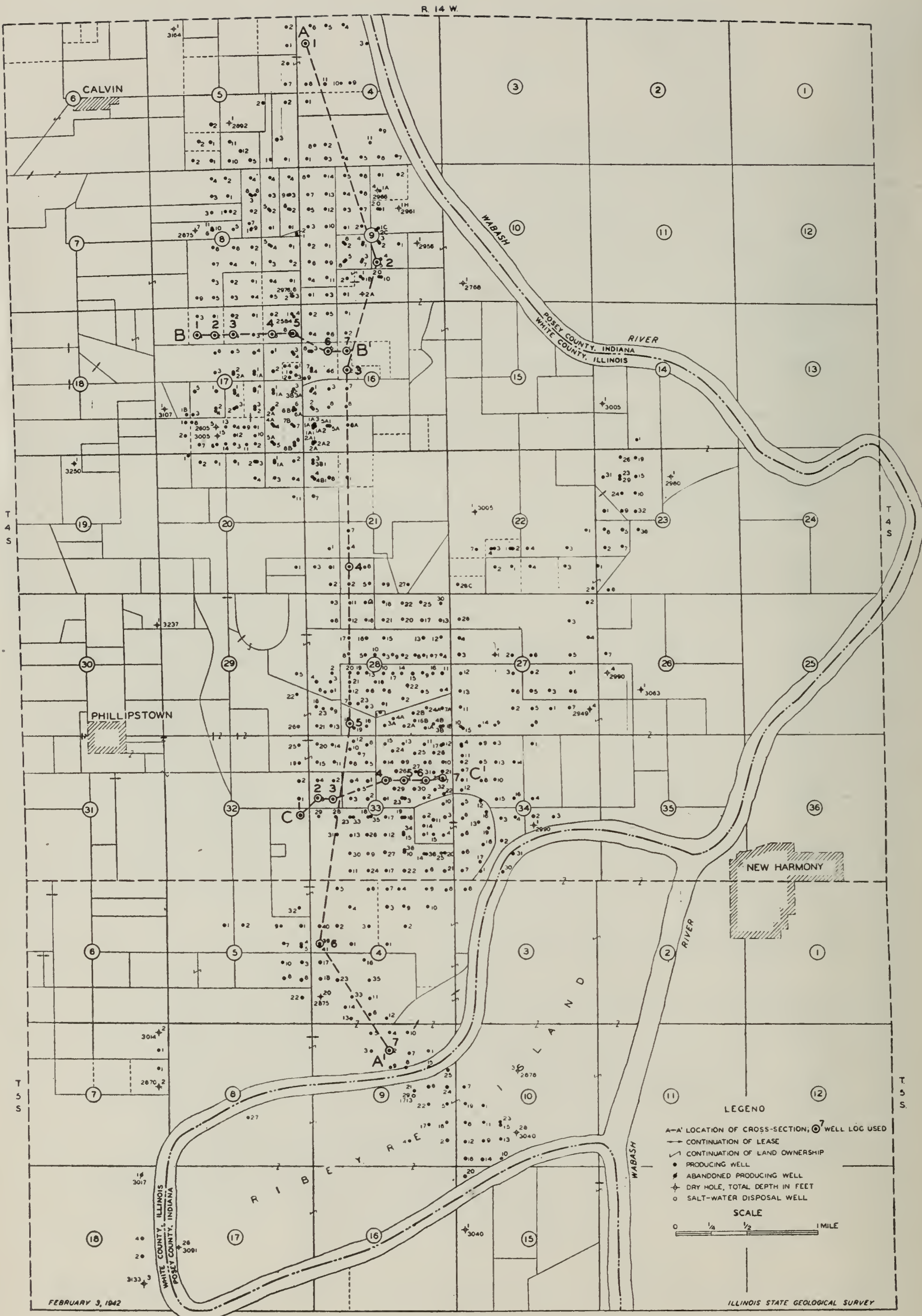

FIG. 3.—New Harmony field (consolidated), White County, Illinois, and Posey County, Indiana, showing location of electric-log cross sections.

dip is at the rate of 160 feet per mile. This is comparable to the amount of dip on the west side of the LaSalle anticline in certain areas.

ELECTRIC-LOG CROSS SECTIONS

Three electric-log cross sections in the New Harmony field were prepared: section *AA′* north and south, *BB′* east and west across the north half of the pool, and *CC′* east and west across the south half of the pool (Fig. 3). Correlation of the Chester producing sands in the field is shown for each well.

In section *AA′*, which extends north and south through the field, the wells whose records have been used average from a mile to 1½ miles apart (Fig. 4). The total distance represented by the cross section is 7 miles. The log of well 7 is a sample study adjusted to the electric log of the well.

Considerable variation is noted in the sandstones of the Clore and Palestine formations. The Waltersburg formation is mostly shale in well 1, but it becomes more sandy southward and in well 4 it is a fairly well developed sand. Farther southward, in wells 5 and 6 it is again more shaly, and in well 7, in the extreme south end of the field, it is again a fairly well developed sand. The Tar Springs formation in well 1 is a well developed sand at its base, with alternating shale and sandstone in the upper part of the formation. The formation thickens southward and in well 4 shale is present in the lower part. It becomes a uniform sand body in the area of well 5, but in well 6 the entire formation consists of sandstone lenses and shale.

The sandstone in the Cypress formation is thin and poorly developed in wells 1 and 2 in the north part of the field but is thicker and more uniform southward to the extreme south end of the field, where it becomes somewhat shaly.

The sandstone member of the Paint Creek is fairly well developed in the area of well 2, in the north half of the field, but is predominantly shale in the south part of the field.

Bethel sandstone is poorly developed in well 1 in the extreme north end of the field but is better developed southward. The Aux Vases sandstone shows little variation in character in the cross section. The low resistivity curve on the electric log ordinarily shown by the sandstone, even where it is well saturated with oil, is thought to be due to the high content of connate water.[5] Variation in the area of production of the sand is largely due to the varying amounts of calcium carbonate cementing material.

Cross section *BB′* extends from west to east across the north half of the New Harmony field, which is one mile wide at this point (Fig. 5). Most of the wells are one location (660 feet) apart, and the greatest distance between any two wells is approximately ¼ mile.

The Kinkaid limestone has been truncated on the higher part of the structure and is present only on the east side. There is considerable variation in the uppermost Chester sandstones from west to east across the field in the area of the cross

[5] Everett F. Stratton, Schlumberger Well Surveying Corporation, personal communication.

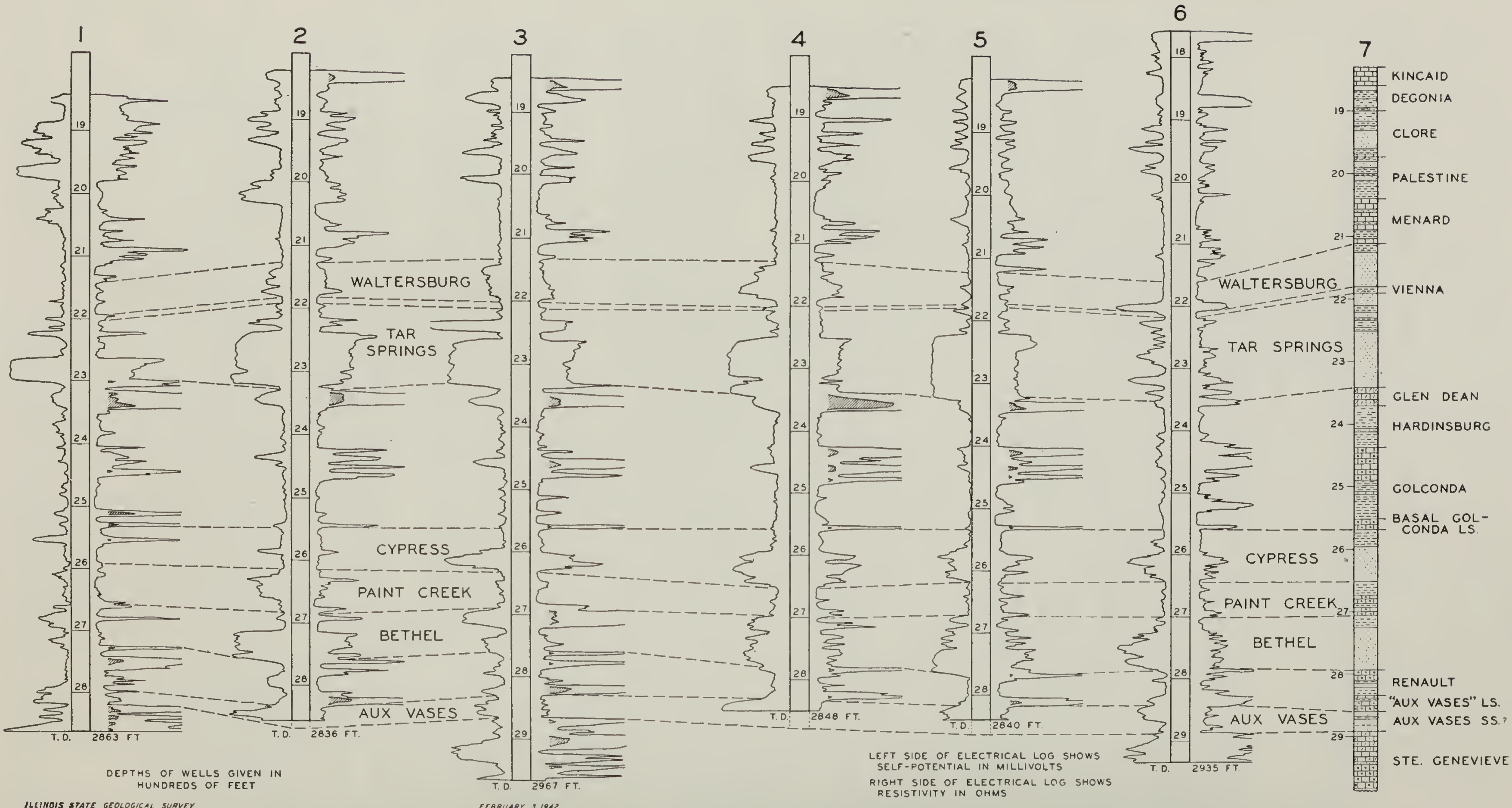

FIG. 4.—New Harmony field, north-south electric-log cross section *AA'*.

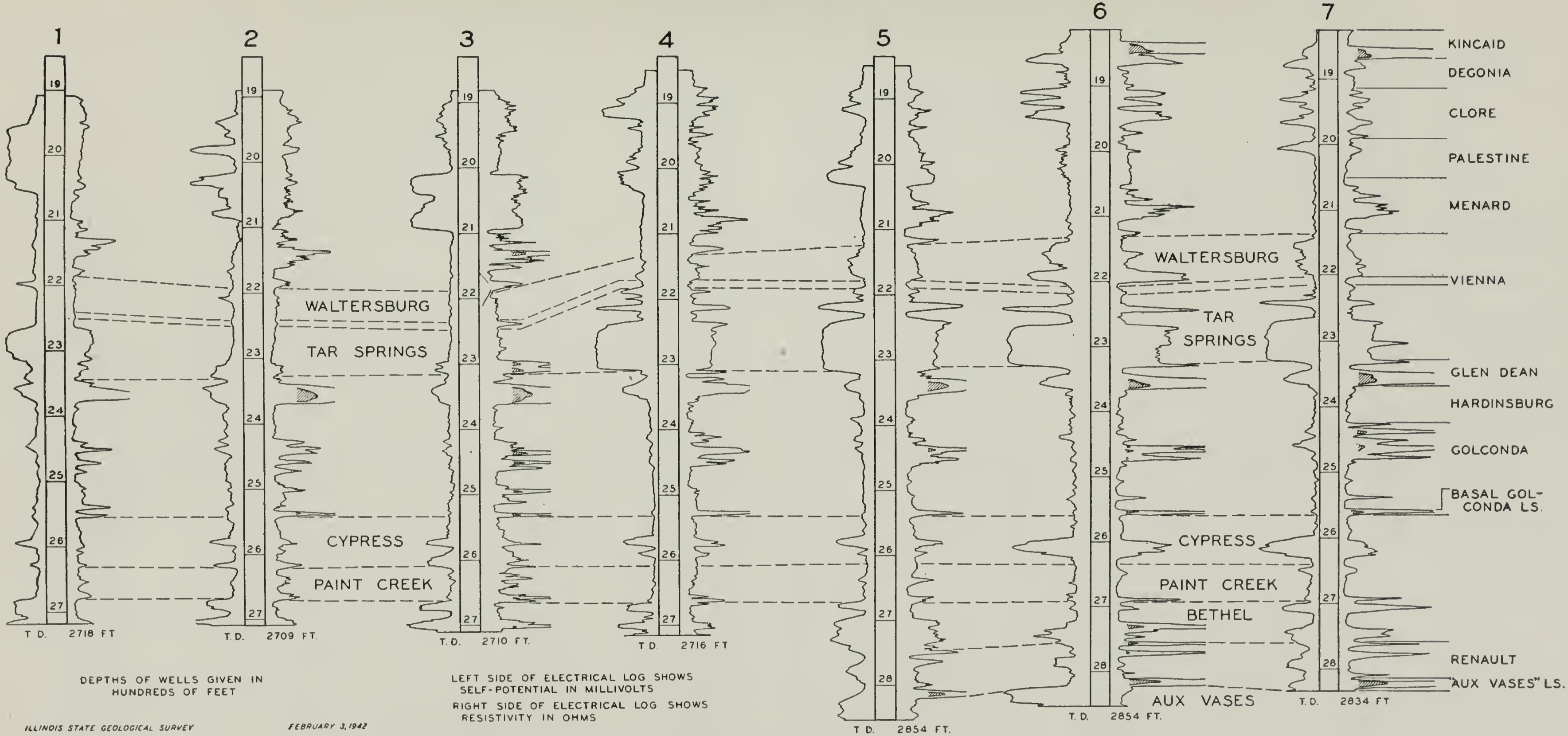

FIG. 5.—New Harmony field, west-east electric-log cross section *BB'*.

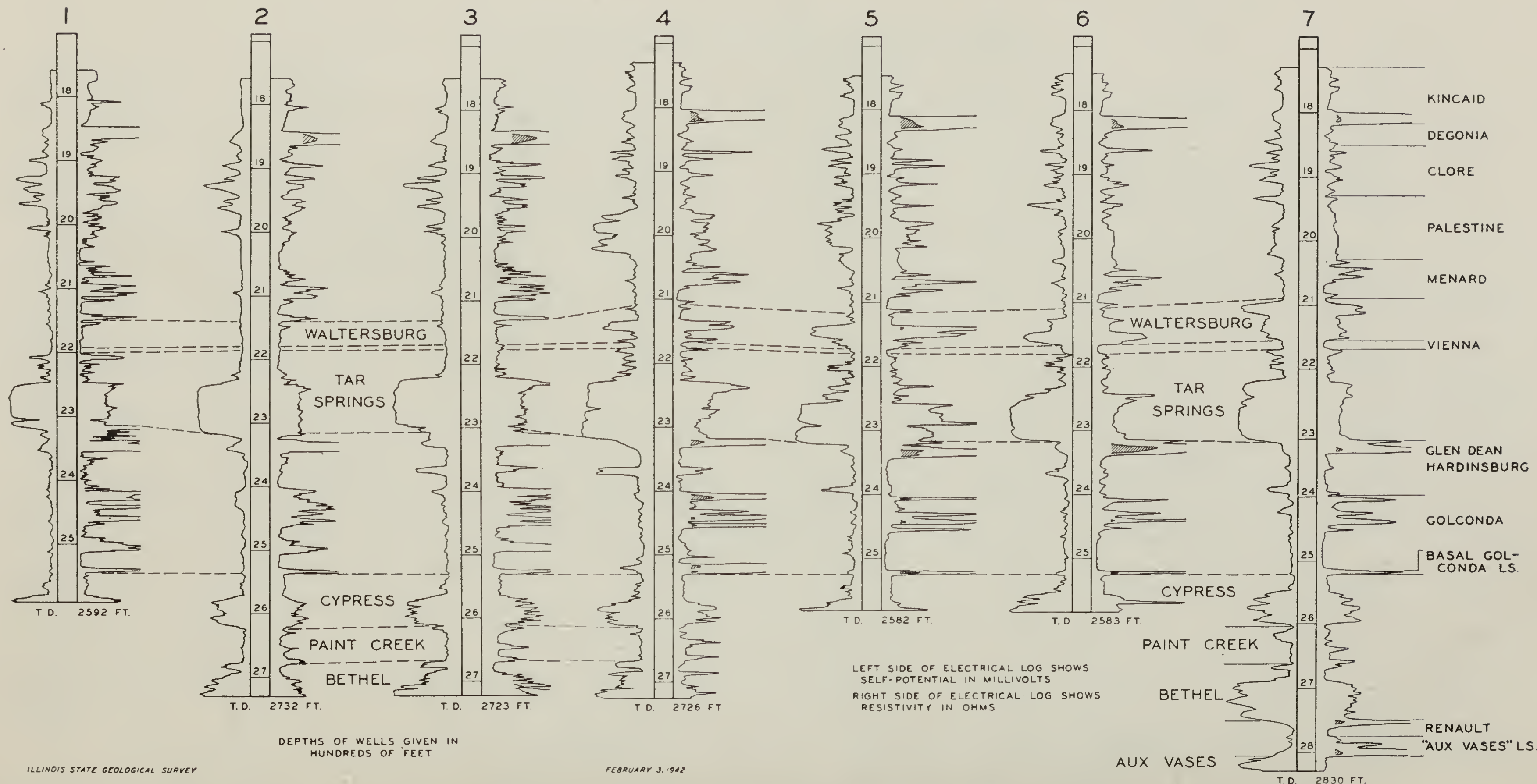

FIG. 6.—New Harmony field, west-east electric-log cross section *CC′*.

section. The Palestine sandstone is poorly developed in wells 6 and 7 on the east side but thickens westward with some lithologic variation, and on the west side of the field in well 1 it is in contact with the overlying sandstone member of the Clore, making a continuous sand body 100 feet thick.

The Waltersburg sandstone is fairly well developed in well 6 on the east side of the field but in other wells of the cross section it is predominantly shale.

The Tar Springs sandstone is very thin in wells 2 and 3 but is a thick sand body in wells 4, 5, 6, and 7.

The Cypress sandstone thickens and becomes a more uniform sand body from west to east. The Paint Creek formation is somewhat sandy in part of the area but in general it is principally shale with some lenticular sand bodies. The Bethel sandstone shows variation in thickness in both the upper and lower beds which are separated by shale.

Cross section *CC′* extends from west to east across the south half of the New Harmony field (Fig. 6). The length of the section is one mile. All wells are approximately one location (660 feet) apart, except that wells 3 and 4 are slightly more than $\frac{1}{4}$ mile apart.

The Palestine sandstone is thin and poorly represented in wells 6 and 7 on the structure. In wells 4 and 5, which are as high structurally as wells 6 and 7, the sandstone is well developed but contains water.

The Waltersburg sandstone is fairly well developed in wells 4, 5, 6, and 7, particularly in well 7, but on the west edge of the field the formation is almost entirely shale.

The Tar Springs sandstone shows some variation in thickness in the area of the cross section. The sandstone in the Hardinsburg formation is poorly developed in wells 1 and 2 but becomes better developed in wells 3, 4, 5, and 7.

The Cypress sandstone is fairly uniform in character.

PRODUCTIVE AREAS OF SANDSTONES

Waltersburg sandstone production has been limited to the south half of the field and occurs in rather small irregular areas as a result of the lenticular character of the sand (Fig. 7).

Tar Springs production occurs in the thin lenticular sand body at the top of the formation which is present in small areas in both the north and south parts of the field. The massive sandstone below ordinarily contains much water in this area. Although there are considerable variations in the sand, it is a well developed sand body in most of the field (Fig. 7).

Cypress production is limited in the north half of the field but includes a fairly large area in the south half where the sand is more fully developed (Fig. 7).

The Paint Creek-Bethel sandstone production is limited to the north half of the field where the sand is best developed. The formation thins southward and becomes shaly in the south half of the pool (Fig. 8).

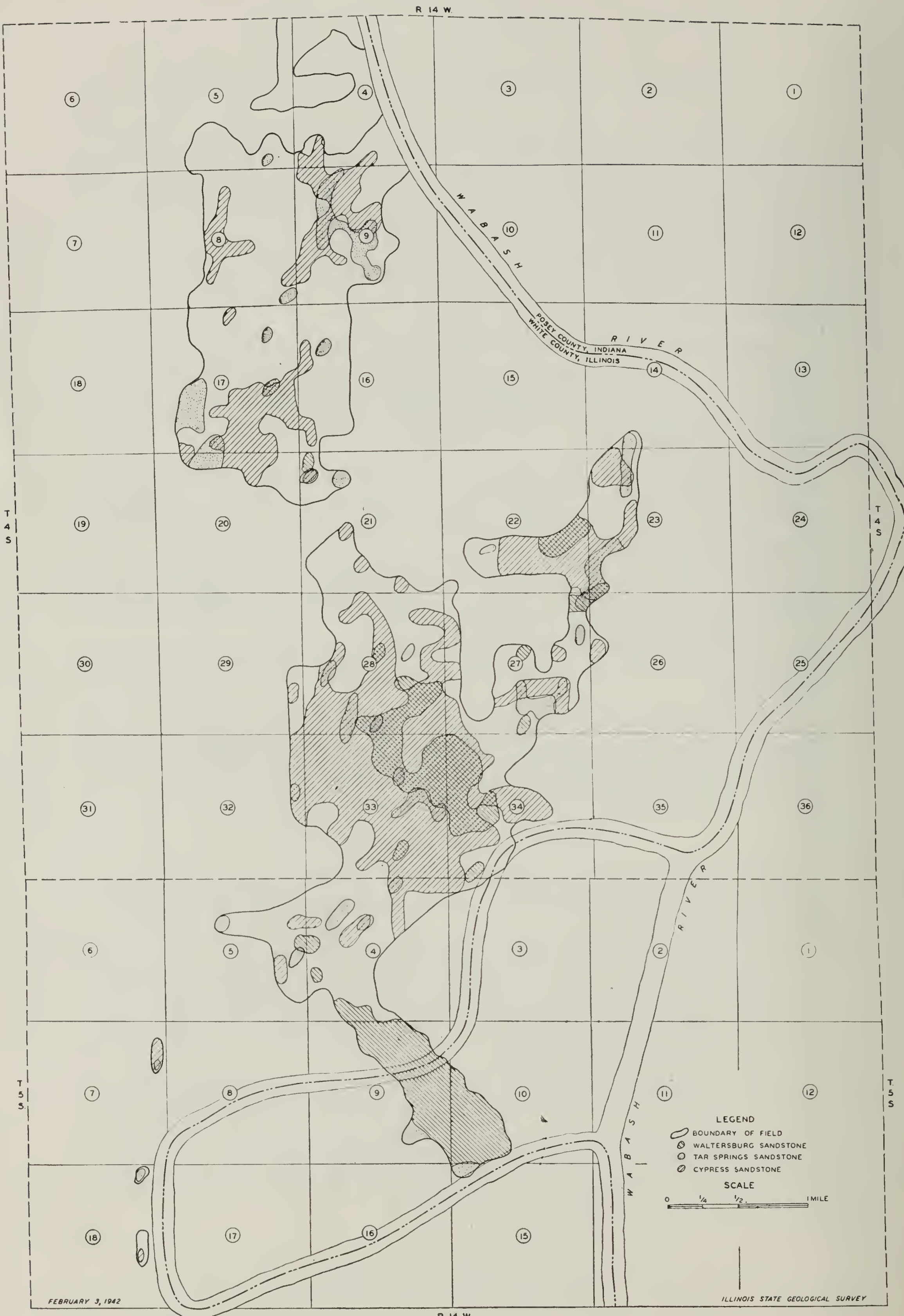

Fig. 7.—Areas of present production and reported saturation of Waltersburg, Tar Springs, and Cypress sandstones in New Harmony field.

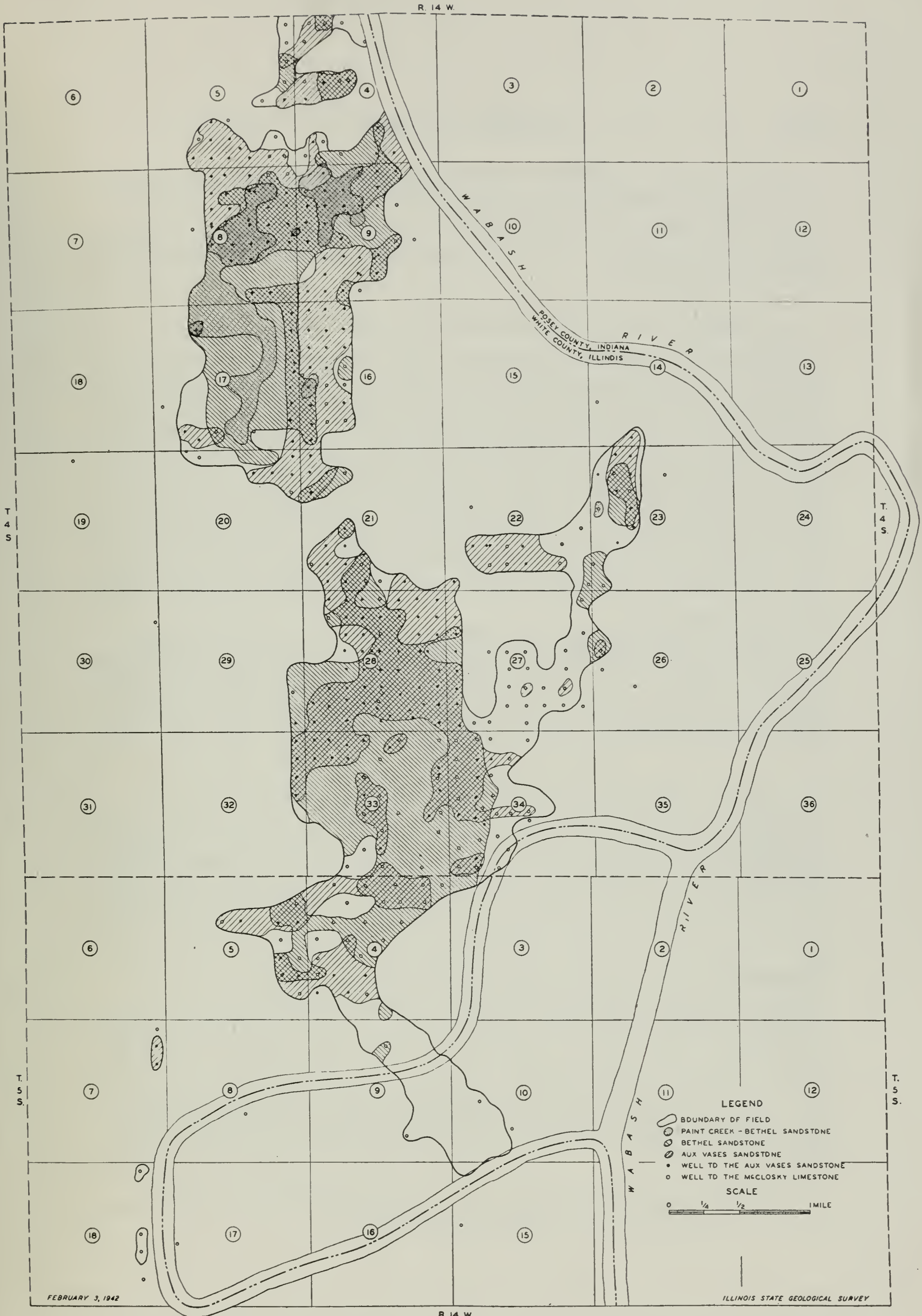

FIG. 8.—Areas of present production and reported saturation of Paint Creek-Bethel, Bethel, and Aux Vases sandstones in New Harmony field.

Bethel sandstone production occurs in irregular areas in both the north and south parts of the New Harmony field (Fig. 8).

Aux Vases production, like the Bethel, includes a large area in each part of the field. Irregularity of the producing area is largely due to the calcareous character of the sand (Fig. 8).

LITHOLOGY OF SANDSTONES WITH REFERENCE TO OIL PRODUCTION

Core studies of the producing Chester sands in the New Harmony field show that the sands are fine-grained to very fine-grained and vary from massive to thin-bedded sand bodies with numerous shale partings. The cementing material is generally silica but calcareous cement was noted in some of the cores. The Aux Vases sandstone differs from the other Chester sandstones in its calcareous content. The fine quartz grains are cemented with a varying amount of calcium carbonate throughout the field. In some areas in the field the amount of calcium carbonate is so great that the sand is not porous or permeable enough to produce. It is customary practice to shoot the sand with nitroglycerine, and in the south part of the field some of the Aux Vases sand wells were shot with 600 or more quarts of nitroglycerine.

Subsurface studies in southern White County south of the New Harmony field and in Gallatin County suggest that the sandstone which is called Aux Vases in the New Harmony field is the Rosiclare sandstone in subsurface studies of Hardin County. According to this correlation the limestone called Aux Vases may be the Levias limestone of Hardin County.

NEAR-SHORE DEPOSITION OF RECENT SEDIMENTS

Studies of continental shelf sediments aid in the interpretation of conditions of deposition during geologic time. A study of the sediments of Santa Monica Bay off the coast of California revealed that areas of silt and sand, fine sand, sand and gravel, and rocky bottom all occur within a mile from shore and within a depth of 10 fathoms.[6] Similar irregularity in the character of the sediments was found throughout the bay. However, near shore, in depths of a few fathoms, the sediment is on the average just as fine as that far out on the shelf.

Cores which were taken approximately 2,000 feet from shore and in 25 feet of water and which penetrated into the bottom 22–25 feet showed stratification of the sediments. The upper 3–12 feet of the cores were silt and fine sand, becoming finer with depth. Below this layer was sand of variable thickness and coarseness. Two cores had gravel beds at an appreciable depth. The layers were somewhat lens-shaped. There appears to be no general regularity of deposition, either laterally or vertically.

[6] F. P. Shepard and G. A. MacDonald, "Sediments of Santa Monica Bay, California," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 22, No. 2 (February, 1938), pp. 201–16.

DEPOSITION OF CHESTER SANDSTONES

According to what is known about the character and distribution of recent sediments on the continental shelf, the lithologic variation of the Chester sandstones in the New Harmony field indicates that they were deposited near shore in advancing Chester seas. As the sandstones are generally composed of very fine to fine sand grains, the writer is of the opinion that the sediments were supplied by a relatively low land mass traversed by large streams having low gradients. Sedimentation involved current action and wave action, which affected distribution of the sediments as they were carried in, and reworked unconsolidated alluvial[7] sediments already deposited. Under such conditions sand bars[8] undoubtedly developed and other irregular sand bodies were deposited. These deposits may or may not have remained as deposited, depending on the depth of the wave action and variation of the currents. As the sea advanced farther inland the sand deposits became more stable and finally were covered and preserved by later sediments. After compaction and consolidation of the sediments, the resulting rock strata were lenticular or more probably disc-shaped[9] sand bodies that graded laterally into siltstone or shale, or were "sheet sands" that varied considerably in character.

Where the Tar Springs formation is predominantly shale there is a thinning of the interval between the Menard and Glen Dean limestones. Where the Vienna limestone is present the same thinning is observed between it and the Glen Dean limestone. This thinning of interval, the greatest of which amounts to approximately 18 per cent, is probably due to non-deposition and greater compaction of the Tar Springs sediments where they are principally shale.

The variable reservoir conditions found in the Chester sandstones in the lower Wabash Valley area make successful drilling within the fields uncertain. As a guide to further exploration within the area of development, it is suggested that isopach maps should be prepared for each producing sand to determine the extent and variation of the sand body in addition to lithologic studies of the cores and the study of water conditions within the reservoir.

ACKNOWLEDGMENTS

The study was made possible by the electrical logs and other data furnished by the various oil companies having wells in the area. Their assistance is greatly appreciated. The writer is grateful to members of the Survey staff for helpful suggestions in the study.

[7] J. Marvin Weller and A. H. Sutton, "Mississippian Border of Eastern Interior Basin," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 5 (May, 1940), p. 847.

[8] Charles Brewer, Jr., "Genetic Relationship of Oil Reservoirs to Shoreline Deposits," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 6 (June, 1928), p. 600.

[9] Charles Brewer, Jr., *op. cit.*, p. 604.